Bureau of Land Management, Incident-With-Potential, NXX
Burns, OR.

Executive Summary

On Sunday, September 14, 2014, a Bell 206L-1 (NXX) contractor owned and operated aircraft was involved in a mishap while conducting a fire suppression operation approximately 50 nautical miles south of Burns, Oregon. The fire suppression mission was in response to a scheduled prescribed burn for the Moon Hill RX that exceeded the set boundary (although within the designated project area). The mission was under the operational control of the BLM.

An ignition specialist controlling the fire was in a separate helicopter (NXXX) while NXX (mishap aircraft) was igniting the surface with an attached helitorch. A spot fire erupted on the west side of the burn area where there was a small rise in terrain. The ignition specialist directed NXX to return to the Moon Hill Helibase, off-load the helitorch, and return with a Bambi bucket to help extinguish the spot fire.

At approximately 1620 Pacific Daylight Time (PDT)[1] the mishap pilot departed the helibase with the helicopter configured with a 108 gallon Bambi bucket cinched to 80%. NXXX joined up and followed him to the dip site and then to his first drop.

Given the fire activity, time of day, and ground access to the spot fire, the Ignition Specialist directed the aircraft he was flying in NXXX to return and reconfigure with a Bambi bucket to assist with the fire suppression effort if needed. After observing NXX's first drop, NXXX departed for the helibase to reconfigure.

The mishap pilot filled the Bambi bucket a second time and dropped water on another spot fire that he discovered while working on the original spot fire. Prior to dropping the water from the bucket, the pilot noticed a small 6 to 8 foot fire whirl had developed on the spot fireline edge. A fire whirl, also colloquially known as a fire devil or fire tornado is a whirlwind induced by a fire and often made up of flame. Fire whirls may occur when intense rising heat and turbulent wind conditions combine to form whirling eddies of air. These eddies can tighten into a tornado-like structure that sucks in burning debris and combustible gases.

While pulling up from the drop, the pilot felt the aircraft climb rapidly. In response, he lowered the collective (reduced power) in an attempt to arrest the climb, but the aircraft kept climbing.

The pilot stated that he then heard a loud "bang" and felt "tightness" in the controls. Once the aircraft was stabilized, the pilot said he looked down to check on the bucket but didn't see it. When he looked to the back of the aircraft, he saw that the bucket was draped over the tail boom with the cable still attached, just a few feet away from the tail rotor.

The pilot immediately looked for a safe landing zone away from the flame front. He located a

[1] All times are Pacific Daylight Time (PDT) unless otherwise noted.

safe landing zone approximately 75-100 yards from the fire and landed at approximately 1630.

Once on the ground, the pilot shut the aircraft down, exited the aircraft, removed the bucket from the tail boom, and inspected the main rotor blades, tail section and the tail rotor. With no indications of damage to the main rotor blades and only minor damage to the tail rotor, the pilot decided that the aircraft could be flown back to the helibase.

At approximately 1650, the mishap pilot (hereafter also known as "the pilot") noticed that fire activity was intensifying and heading towards the aircraft. The pilot re-attached the cable and Bambi bucket to the aircraft, lifted the aircraft into a hover, tested the controls and decided the aircraft was capable of flying back to the helibase.

NXXX arrived back on scene about the time the mishap pilot had started the aircraft.
The two aircraft flew back to the Moon Hill Helibase at an altitude of approximately 200 feet above ground level (AGL) and airspeed of approximately 40 knots. Landing at the helibase was uneventful.

CONTRIBUTING FACTORS:

Gusting winds resulting in the formation of a "fire whirl" was a contributing factor in this mishap (paragraphs 27-33). At the time of the incident, the Malheur Portable Remote Automatic Weather Station (RAWS) data indicated the wind was gusting up to 18 mph. Fire whirls may occur when intense rising heat and turbulent wind conditions combine to form whirling eddies of air. These eddies can tighten into a tornado-like structure that sucks in burning debris and combustible gases. The pilot stated that he felt the aircraft climb at approximately 3,000 feet per minute immediately after releasing water from the bucket and seeing the fire whirl.

SEQUENCE OF EVENTS

Background.

On Saturday, September 13, 2014, the mishap pilot arrived in Burns, Oregon in preparation for an upcoming BLM prescribed burn mission.

On Sunday, September 14, 2014 at 0800, a mission brief was conducted at the Burns BLM Helibase located at the Burns municipal airport. The brief consisted of project objectives, safety and emergency procedures for personnel involved in the prescribed mission. After the brief, the pilot departed for the Moon Hill Helibase, located approximately 36 miles south southeast of the Burns municipal airport.

The mishap aircraft, NXX a 1978 Bell 206L1 C30P, was initially configured with a helitorch used for aerial ignition of ground fuels (Figure 1and 2).

Figure 1. Generic picture of a helitorch

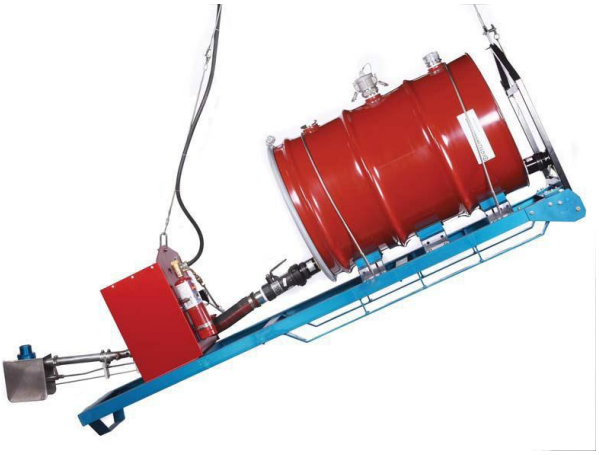


Figure 2. Helitorch attached to a helicopter

According to the pilot, helitorch operations were in progress from 1230 to approximately 1600.

At approximately 1530, the holding crew on the south end of the fire noticed spot fires erupting across the boundary line (but still within the designated project area). The pilot was on his way back to the helibase for another barrel of fuel for the helitorch when he got the call from the Ignition Specialist in aircraft NXXX directing him to reconfigure for fire suppression. The pilot landed and shut down to add fuel, remove the helitorch and to hook up the Bambi bucket. After performing the required preflight checks, he departed at 1620 for the fire with approximately 375 pounds of fuel on board.

Mishap Flight

The Bambi bucket, model 9011, [2] was cinched to 80% which allowed 86 gallons of water to be drawn and delivered. A 100 foot, 5/16" steel cable attached the bucket to the aircraft.

Figure 3. Representative photo of a Bambi bucket.

On the way out to the south boundary, the pilot received the name and position of the ground contact from the ignition specialist. The pilot contacted the ground contact and proceeded to draw water from a pond located southeast of the drop position. NXXX joined up and followed him to the dip site and then to the fire to observe his first drop.

[2] At 100% capacity, the Bambi bucket model 9011 is capable of holding 108 gallons of water.

Figure 4. Moon Hill RX Burn area.

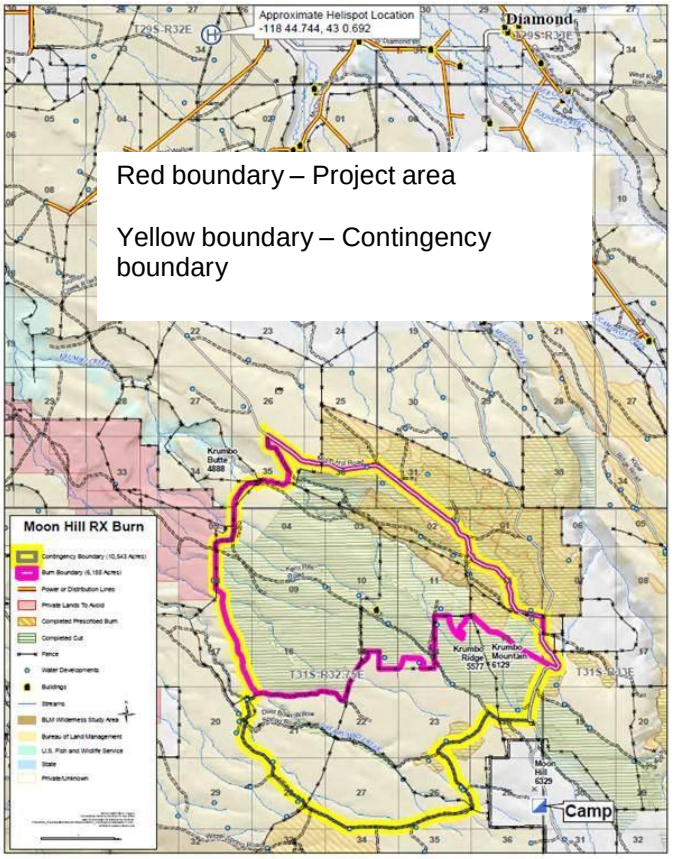
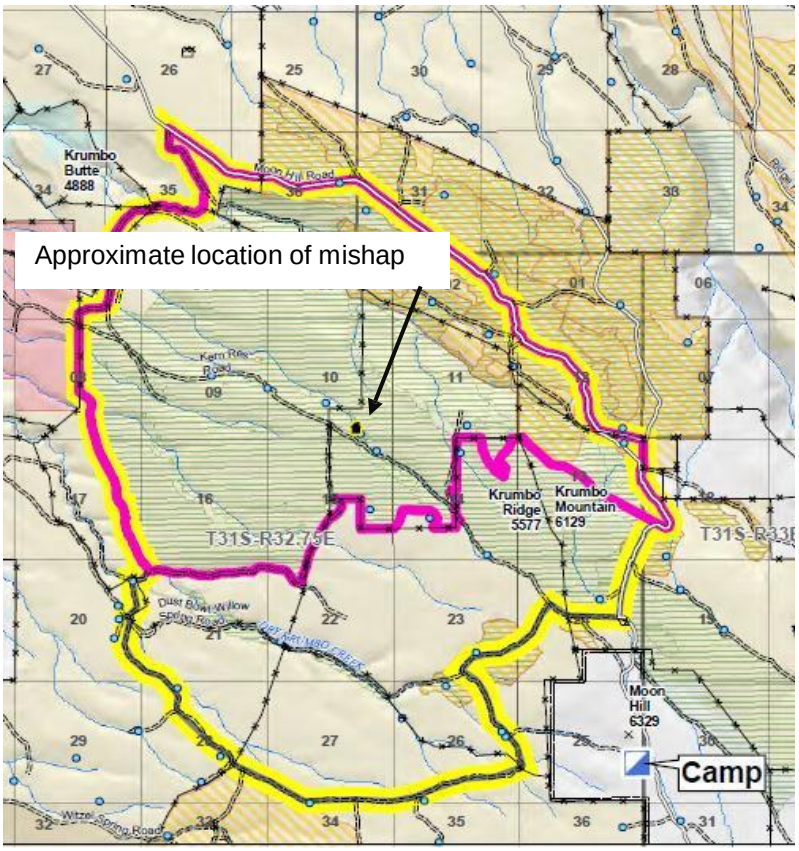


Figure 5. Mishap location.



The pilot was requested to slow the fire spread to the east but smoke laid over the area. Unable to get in to the eastern portion of the area, he informed the ground contact of the smoke and told him that the southeast area in front of the first eastbound Tatra engine[3] was accessible. The pilot performed a trail drop with the first bucket of water about 200 yards east of the Tatra in a westbound direction on the southern flank. The pilot stated that the drop was uneventful with wind out of the west at 8 knots or less. After the drop, the pilot returned to the dipsite to refill the Bambi bucket with water.

Given the fire activity, time of day, and ground access to the spot fire, the Ignition Specialist directed NXXX to reconfigure with a Bambi bucket to assist with fire suppression if needed.

After observing NXX's first drop, NXXX departed for the Moon Hill Helibase.

On the way back to the fire with the second bucket, the pilot noticed another spot fire farther to the east that was cresting the small ridge above the south boundary road. The pilot

[3] A Tatra engine is a six-person crew cab, 6x6 all-wheel drive fire-fighting vehicle with a 2,400-gallon water/foam carrying capacity.

made a long left base to final into the wind for another trail drop across the head of the spot fire that just started on the flat above the ridge.

The pilot came in straight with a shallow descent on final to have the bucket about 40 feet above the terrain and Juniper trees. The fire was moving through the grass in a southeasterly direction just 10 feet from the crest of a ridge.

On short final, the pilot was set up for a trail drop with an airspeed of approximately 15 - 20 knots. He noticed a small fire whirl starting to form at the head as he looked down at the bucket to make the drop. As soon as the pilot dropped the water, he noticed that while the helicopter's attitude and heading remained constant, the aircraft was rapidly climbing. He shifted his focus back inside the aircraft in order to stabilize the climb. He then lowered the collective (reduced power) and held the attitude and heading steady.

With the collective lowered to around 30 % torque, the pilot stated that he heard a loud "bang." The helicopter continued to climb for a few more seconds then smoothly leveled out at an airspeed of approximately 20-30 knots in a westerly direction. As he pushed the cyclic forward to gain airspeed, he felt "tightness" in the controls.

When the pilot looked outside to check the bucket, he noticed it wasn't below the aircraft, but was behind the aircraft, hanging off the back of the left horizontal stabilizer. The cable was within a foot or two from the tail rotor with the bucket approximately 60 -70 feet below. The cable was causing the resistance to cyclic inputs by resting on the aileron on the back of the horizontal stabilizer.

The pilot lowered collective (reduced power) and eased back on the cyclic to reduce airspeed and slowly descend without getting the line any closer to the tail rotor arc. The pilot made a call to NXXX (who after watching the first bucket drop was heading back to base to reconfigure with his bucket) and told them that he was landing.

With airspeed less than 5 knots, the pilot landed in the first opening he saw. He landed the bucket in front of the aircraft and kept the line tight while backing and descending, careful not to put any slack in the line. When the skids were firmly on the scab rocks, he reduced the throttle to idle and performed a normal shutdown. He then climbed out and inspected the tail rotor blades, main rotor blades, tailboom and associated components.

According to the pilot, "there was a one inch mark on the outboard leading edge of one of the tail rotor blades (approximately .001 to .0015 inch deep scratch that did not show evidence of breaking through the stainless steel leading edge or delamination) that had made contact with the cable and electrical cord. There were no cracks on either tail rotor blade – span wise or length wise. Both pitch change links felt good, the knurled nut and balance wheel were still tight and safety wired, and neither side blade bearing had any play. The gear box was solidly mounted and full of oil and the pitch change shaft and vertical stabilizer had no signs of damage."

The pilot then inspected the cable to find any evidence of a blade strike. Approximately 40% of the 5/16" cable was cut and the electrical cord was severed 22 feet aft of the helicopter attach point (belly cargo hook). He then inspected the main rotor for damage and found nothing on either blade. Both blades are equipped with clear rubber tape on the outboard 7 feet of the leading edge. With no tears in the tape or evidence of contact, the pilot determined that the main rotor blades appeared airworthy, as did the tail rotor drive shaft cover, PC links and rotor head.[4]

From the top of the helicopter the pilot could see the fire advancing towards his position from the north. With the rate of spread he guessed he had 5 to 8 minutes to depart. He climbed down and removed the cable from the tail boom.

The pilot stated that he wanted to disconnect and load the bucket and long line in the back of the helicopter but did not have time. He stated that the minimum break rating for 5/6" cable is 8,500 pounds and he was confident that there was at least 50 to 60% of good cable remaining and estimated the breaking weight was at least 4,000 pounds, which exceeds the helicopter lifting capability by 4-5 times. He reattached the pear link to the cargo hook and prepared for takeoff.

By the time NXX was started, NXXX was on scene. NXXX ensured communication and escorted the mishap aircraft back to the Moon Hill helibase at an airspeed of approximately 40 knots and at an altitude of approximately 200 feet AGL. The pilot stated that the helicopter flew fine with no vibration in the pedals or cyclic and that all cockpit indications were normal with no warning or caution lights illuminated.

The flight back to the helibase and subsequent landing were uneventful. Photos taken later of the precautionary landing site confirmed that the fire had overrun the location.

On October 3, 2014 the inspection and replacement of sudden stoppage items were completed and the aircraft was returned to service.

The tail rotor blade returned to the manufacturer was found to be serviceable. The blade was cleaned, smoothed and returned to the contractor.

Facts, Analysis, and Contributing Factors

Methodology

Aircraft mishaps are the result of a chain of diverse, yet interconnecting links (events) that together produce unintended, yet predictable consequences. Each link can be sorted into one of several broad categories. Each category lends itself to certain preventative and prescriptive measures that if applied to future operations can preclude the forging of one or more of the links

[4] The pilot's determination that the aircraft was airworthy was made from his knowledge of the aircraft. He was not a designated Airframe and Powerplant (A&P) mechanic.

in a mishap chain. These links are identified through the mishap investigative process and are expressed in terms of ***"contributing factors."*** In aircraft mishaps, a contributing factor is identified as a deviation from expected norms that compromises established safeguards and risk mitigations and brings the pilot-aircraft system closer to a mishap. Other deviations to accepted norms uncovered during the investigation that did not contribute to the mishap, but should be corrected are characterized as "present but not contributing." **Preventing an aircraft mishap requires that only one link (contributing factor) in the mishap chain be broken.**

The Department of the Interior, Office of Aviation Services (OAS) employs the Air Force 5M model, [AFPAM 90-803, Risk Management (RM) Guidelines and Tools] as the framework for aircraft mishap reporting. The 5-M's are ***Media, Machine, Mission, Man,*** and ***Management***. These categories capture the broad range of elements that interact as a system to produce mission success or mission failure. Successful missions or mishaps do not just happen; they are the product of a system that includes Media, Machine, Mission, Man, and Management. Mishaps serve as indicators of how well a system is functioning and where improvements can be made to increase mission success and reduce loss/cost.

MEDIA

The Malheur portable RAWS station (TS674) was located approximately 3.5 miles from the mishap site. The weather data for September 14, 2014 is shown in Figure 6.

Figure 6. Weather data on the day of the mishap.

Time PDT	Temp° F	Dew Point °F	Relative Humidity %	Wind Speed mph	Wind Gust mph	Wind Direction
11:58	76	26.6	16	8	14	WSW
12:58	79	24	13	7	13	WSW
13:58	81	23.6	12	5	18	WSW
14:58	82	24.4	12	4	18	WSW
15:58	81	25.5	13	6	15	N
16:58	82	24.4	12	7	20	NNE
17:58	80	24.7	13	3	11	NNE

At the time of the incident, the wind was gusting up to 18 mph, with an associated wind shift from the west southwest to the north northeast. The mishap pilot stated that as he made the last water drop, he witnessed a 6 to 8 foot fire whirl starting to form.

A fire whirl, also colloquially known as a fire devil or fire tornado is a whirlwind induced by a fire and often made up of flame. Fire whirls may occur when intense rising heat and

turbulent wind conditions combine to form whirling eddies of air. These eddies can tighten into a tornado-like structure that sucks in burning debris and combustible gases.

A fire whirl consists of a core—the part that is actually on fire—and an invisible pocket of rotating air that feeds fresh oxygen to the core. The core of a typical fire whirl is 1 to 3 feet wide and 50 to 100 feet tall. Under the right conditions, large fire whirls, several tens of feet wide and more than 1,000 feet tall can form. The temperature inside the core of a fire whirl can reach up to 2,000 °F - hot enough to potentially reignite ashes sucked up from the ground. Often, fire whirls are created when a wildfire or firestorm creates its own wind, which can turn into a spinning vortex of flame.

Combustible, carbon-rich gases released by burning vegetation on the ground are fuel for most fire whirls. When sucked up by a whirl of air, this unburned gas travels up the core until it reaches a region where there is enough fresh, heated oxygen to set it ablaze. This causes the tall and skinny appearance of a fire whirl's core.

Real-world fire whirls (Figure 7) usually move slowly. Fire whirls can set objects in their paths ablaze and can hurl burning debris out into their surroundings. The winds generated by a fire whirl can also be dangerous. Large fire whirls can create wind speeds of more than 100 mph strong enough to knock down trees.

Figure 7. Representative photo of a fire whirl approximately 40- 50 foot tall.

The pilot stated that he felt the aircraft climb at approximately 3,000 feet per minute (fpm) just after seeing the fire whirl. As he reduced power to arrest the rate of climb, the Bambi bucket was still influenced by the very strong updraft. During the short period of time between the large power reduction, level off and continued ascent of the Bambi bucket, the 100 foot cable wrapped around the tail boom, missing the main rotor blades and only impacting one tail rotor blade.

While there are no defined procedures for what to do in the event of encountering a fire whirl, other very experienced helicopter pilots opined that the best procedure would be to "hold what you have." In other words, do not reduce power but maintain forward speed in order to fly out of the pronounced updraft.

According to the pilot, the cable came up in front of the right horizontal stabilizer, went over the tail boom and behind the left stabilizer (figure 8). There were no witnesses to the event.

Figure 8. Re-enactment of the cable wrapped around the tailboom.

Media – gusting winds resulting in the formation of a fire whirl was a contributing factor in this mishap

MACHINE

NXX was a 1978 Bell 206L1 C30P[5] configured with a 5/16 inch, 100 foot steel cable. At the end of the cable was a model BB9011 Bambi bucket (Figure 9 and 10, page 13). The BB9011 holds 108 gallons of water[6] and weighs 85 pounds empty with a gross weight of 970 pounds. The Bambi Bucket in use was cinched to 80%, meaning that the bucket could only take and release 86 gallons or 717 pounds of water[7]. The long line was attached to the cargo hook on the helicopter.

The 100 foot cable is authorized for use for DOI missions. The Interagency Helicopter Operations Guide (IHOG), Chapter 9K states that "if a longline is used for water bucket operations, then the longline shall be a minimum of 50 feet in length to reduce the risk of entanglement with the tail rotor or tail boom."

Figure 9. Bambi bucket

Figure 10. Bambi bucket Control Head

The aircraft was equipped with Van Horn tail rotor blades.

The weight and balance / load calculation had been completed for the aircraft configuration and was within limits for the mission.

The aircraft and equipment were properly carded under the authority of the Department of the Interior on March 19, 2014 for the On Call Contract D13PC00145. The mishap pilot stated

[5] C30P designates the Rolls-Royce engine upgrade from the stock engine.
[6] Water weighs 8.34 pounds per US gallon (at 62°F).
[7] The amount of water was restricted due to the operational performance of the aircraft.

that there were no outstanding discrepancies with the aircraft and that it was operating normally at the time of the mishap.
Aircraft carding and operating condition were not contributing factors in this mishap.

Damage to the aircraft.

During the on-site investigation, the aircraft was inspected by an OAS Aviation Safety Compliance Specialist. The inspection was conducted to ascertain the extent of damage sustained to NXX and the maintenance requirements for the aircraft to return to contract availability. The visual inspection was performed in accordance with Bell Helicopter 206L1 Maintenance Manual, Chapter 5, Conditional Inspections, Paragraph 5-53, Sudden Stoppage/Acceleration, Van Horn Aviation, L.L.C. Instructions for Continued Airworthiness, ICA Manual No. VMM-206L1-305, Ch. 5 Inspection/Check Requirements and Lord Corporation SM-6470 Service Manual for Elastomeric Tail Rotor Flapping Bearing Kit for the Bell 206 Series Helicopter.

At the completion of a visual inspection, the only damage identified was the wire rope impact on tail rotor blade and the damage sustained to the long line and electrical cable. The Sudden Stoppage Inspection was performed in accordance with the Manufacturers recommendation (Bell Helicopter Textron), Van Horn's Instructions for Continued Airworthiness and Lord Corporation SM-6470 Service Manual for Elastomeric Tail Rotor Flapping Bearing Kit for the Bell 206 Series Helicopter. Both Tail Rotor Blades were removed and sent to Van Horn L.L.C. for inspection. The Lord Elastomeric Trunnion Bearings and Brackets were to be discarded.

The Non-Destructive Testing (NDT) certifications were competed and annotated in the maintenance aircraft logbook. The rotor blades were inspected and found to be serviceable. The leading edge of the blade with the strike was blended and returned. However, the company installed a complete tail rotor hub assembly with new tail rotor blades.

Aviation Life Support Equipment (ALSE)/Personal Protective Equipment (PPE). The mishap pilot was wearing ALSE/PPE appropriate for the mission flown in accordance with DOI and BLM policy. **Aviation Life Support Equipment/Personal Protective Equipment was not a contributing factor in this accident.**

The Aviation Safety Department at Bell Helicopter was asked if they knew of any similar case where the cable had wrapped around the tail boom on an aircraft. Their response was:
"There have been cases where the line/cable has come in contact with the tail rotor, when there is an empty bucket or line without anything on the end. However this is the first time we have heard of the line becoming completely wrapped around the tail boom."

Bureau of Land Management, Incident-With-Potential, NXX
Burns, OR.

MISSION

The mission was in support of a prescribed fire located approximately 35 miles south of Burns. Oregon. An imbedded mission was fire suppression in the event of spot fires occurring outside the scheduled burn areas (as was the case with this mishap). The prescribed burn was planned and staffed in accordance with the Interagency Helicopter Operations Guide (IHOG) and applicable DOI and BLM instructions.

A September 4, 2014 public affairs announcement issued to the public stated: "HINES,

> Ore. – Fire crews from the Burns Interagency Fire Zone expect to carry out within the next month a large prescribed fire in the Moon Hill area near Krumbo Ridge, approximately five miles southeast of Diamond, Oregon. If weather permits, officials say the project could start as early as next week.
>
> The Burns Interagency Fire Zone does a number of prescribed fire projects annually to reduce fuel loading and the risk of catastrophic large wildfires, increase forage for livestock and wildlife, and improve wildlife habitat. Fire Management Officer Ken Higle said, "These projects are important in our efforts to develop more fire resilient and healthier ecosystems."
>
> The 6,000-acre Moon Hill prescribed fire will last approximately three to seven days. There will be noticeable smoke and increased traffic around the burn area. The public should be aware of the activity and avoid the work site as much as possible."

Well-coordinated and widely distributed, **Mission was not a contributing factor in this mishap.**

MAN

The mishap pilot was an experienced pilot with over 6,300 hours in the Bell 206 series aircraft. He held a FAA commercial rating for rotorcraft aircraft and had a second class medical with no restriction dated October 9, 2013. The pilot was carded by DOI/OAS on June 14, 2014 with a longline vertical reference endorsement. The pilot had over 450 hours of flight time performing longline missions. **Pilot qualification was not a contributing factor in this mishap.**

The mishap occurred on the first day of the project. The pilot arrived in Burns, Oregon on the previous day, Saturday September 13, 2014. Total flight time for the seven days before the mishap was 2.6 hours. Flight time for the day of the mishap was 4.4 hours. He stated that he was well rested and ready for the flight. The pilot's crew day started at 0800 with a morning mission

brief at the BLM UAM office in Burns, Oregon. **Pilot crew day and fatigue were not contributing factors in this mishap.**

The mishap pilot stated that at no time did he encounter a loss of tail rotor effectiveness (LTE) or encounter any un-commanded yaws typical of a LTE event.

MANAGEMENT

The Project Aviation Safety Plan (PASP) was dated and signed by the Associate District Manager on 8/23/13. The PASP remained relatively the same and there was no formal review of the project in 2014. Current policy does not require an annual review.

Department of the Interior Operational Procedures Memorandum OPM 06 states:

> "Project Aviation Safety Plans will be developed for all special use missions. For those bureaus that perform similar special use aviation missions on a recurring or routine basis, the required PASP can be rolled into a station / unit aviation plan that is reviewed at least annually."

The intent of the OPM is to ensure Aviation Plans and Project Aviation Safety Plans are reviewed annually.

A Risk Assessment (RA) was included in the Project Aviation Safety Plan.

The daily Helicopter Operations Brief and the Helitorch Operations Go / No Go Checklists were completed prior to the mission.

CONTRIBUTING FACTORS:

Gusting winds resulting in the formation of a "fire whirl" was a contributing factor in this mishap . At the time of the incident, the Malheur Portable RAWS data indicated the wind was gusting up to 18 mph. Fire whirls may occur when intense rising heat and turbulent wind conditions combine to form whirling eddies of air. These eddies can tighten into a tornado-like structure that sucks in burning debris and combustible gases. The pilot stated that he felt the aircraft climb at approximately 3,000 feet per minute immediately after releasing water from the bucket and seeing the fire whirl.

RECOMMENDATIONS:

1. OAS Training develop a training module on fire tornados and the potential impact to flight operations. Include “best practices” procedures for encountering a fire whirl.

2. BLM reiterate the importance of reviewing PASP that are more than one year old to review and document any changes that might be required.

3. OAS Aviation Safety develop a Lessons Learned Publication to alert all aviation personnel on the dangers of fire tornados.